Vol. 16 No. 2 (2025) 149-157

Jurnal Riset
Teknologi Pencegahan Pencemaran Industri

Journal homepage: https://www.jrtppi.id

Kementerian Perindustrian
REPUBLIK INDONESIA

Bending Test Analysis of Hybrid GLARE Material Using Nano Adhesive CNT and Aluminum Powder Reinforcement

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A R T I C L E I N F O

Article history:

Received: August, 29 2025

Received in revised form September, 24 2025

Accepted: November, 17 2025

Available online: November, 28 2025

Keywords:

Hybrid Laminate Composite

Fiberglass

Aluminum Face Plate

Bending Test

Nanoparticles

Vacuum Bagging

A B S T R A C T

The use of composites as materials has developed rapidly due to the many advantages they offer compared to alternative engineering materials. In this study, the researchers used Glass Laminated Aluminium Reinforced Epoxy (GLARE) to analyze the results of bending tests on hybrid laminate composites reinforced with fiberglass and aluminum plates. The method used was vacuum bagging, and the sample was reinforced with epoxy resin combined with carbon nanotube (CNT) nanoparticles and aluminum (AL) powder. This study applied variations in resin as adhesive, surface treatments, and the addition of CNT and AL nanopowders to determine their effects on the bending strength of the composite. The results showed that specimens with surface treatment and nanoparticle additions had higher bending strength compared to those without nanoparticles or surface treatment. The highest bending stress was found in the CNT variation specimens, with an average value of 181.4158 MPa. The lowest average bending stress was observed in the plain specimens without nanoparticles and surface treatment, with a value of 151.766 MPa. Macro photo analysis after the bending test showed adhesive failure in the plain variation (no resin adhered to the aluminum surface), and cohesive failure in the CNT variation (resin adhered to the treated aluminum surface). These findings indicate that the addition of nanoparticles improves bending strength. This research plays an important role in understanding the influence of nano adhesives and nanoparticles on the bending strength of hybrid laminate composites.

1. INTRODUCTION

The use of lightweight materials in aircraft structures is considered highly important. Lightweight materials play a critical role, and many new materials have been developed that can be applied as alternatives in aircraft manufacturing. The addition of extra weight to an aircraft is disadvantageous both financially and operationally [1].

Considering technological developments and environmental concerns aimed at improving engineering materials, the use of metals—especially steel—in the manufacturing sector has been declining. As a result, composite materials reinforced with natural fibers are being developed due to increasing demand for materials that are not only strong but also lightweight, inexpensive, corrosion-resistant, and environmentally friendly.

A composite is a type of material composed of two or more substances with different properties that are

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doi: https://10.21771/jrtppi.2025.v16.no2.p149-157

Accreditation number: (Ristekdikti) 158/E/KPT/2021

combined or integrated. The base materials usually consist of fiber (used as reinforcement) and a core material that binds the fibers together [2].

The advantage of using composites lies in their directional properties, which allow the material's strength to be tailored for specific applications. Composite materials also offer low density and high strength, making them highly suitable for use in the aerospace industry [3].

Hybrid composites, composed of multiple layered arrangements with unidirectional or specific orientations, have not yet been optimally utilized, presenting an opportunity for further research [4].

Glass Laminated Aluminium Reinforced Epoxy (GLARE) belongs to the Fiber Metal Laminate (FML) group and is a combination of fiberglass and aluminum. This laminate excels in fatigue resistance and its main failure factor lies in its impact resistance [5]. Fiberglass is widely used as a substitute material in the aerospace and automotive industries due to its better mechanical properties and lightweight characteristics. It has a smooth texture, is white in color, and its fiber structure resembles that of a sack [6].

This study uses aluminum series 1100, which is commonly applied in various industrial sectors, especially in lightweight structural components such as aircraft walls, automotive engines, pipes, chemical tanks, and other applications [7].

GLARE can be manufactured using vacuum bagging or hand lay-up methods. The GLARE structure includes aluminum, fiberglass, and epoxy resin. To evaluate the mechanical strength of the specimen under load, an experimental study with specimen variations is required. This necessitates precise procedures and accuracy during specimen fabrication. After manufacturing, the composite undergoes bending tests using the three-point bending method. One known weakness of GLARE composite structures is their low impact resistance [5].

Vacuum bagging is a composite manufacturing process that uses atmospheric pressure to compact the layers, which are sealed inside an airtight plastic bag [8]. The use of vacuum bagging plastic is a common method alongside hand lay-up. It improves on manual hand lay-up techniques by involving vacuum processes to remove excess resin and trapped air from the laminate [9].

In this study, surface treatment variations such as roughening and square grooving were used. These treatments are expected to enhance interlayer bonding, resulting in stronger, more cohesive specimens. Additionally, the study incorporates nano adhesive carbon nanotubes and aluminum powder to further strengthen the material.

Composite technology is supported by the advancement of nanomaterials. Nanomaterial usage contributes to composites with high tensile strength due to their excellent nanotube structures as matrices [10]. Carbon Nanotubes (CNTs) are ultra-thin carbon fibers with diameters measured in nanometers and lengths in micrometers. CNTs have emerged as a promising material for exploration in recent years and are well-known for their exceptional properties, attracting extensive research interest [11]. Similarly, aluminum powder is widely used in the metal processing industry. It undergoes oxidation with oxygen to form aluminum oxide (Al_2O_3), a stable compound that appears as a white powder similar to table salt [12].

The bending test apparatus is used to evaluate the flexural strength of a material. Bending tests are conducted by applying a compressive load, which produces data on the material's flexural properties. There are two types of bending tests: three-point and four-point bending [13]. During testing, the top part of the specimen is subjected to compression while the bottom part experiences tensile stress. The compressive strength of composite materials is generally higher than their tensile strength. Failure typically occurs when the specimen cannot withstand the tensile stress, resulting in fracture at the bottom surface [14] [15].

This research refers to ASTM D-790, which focuses on measuring the strength and stiffness of materials or specimens through bending tests. Therefore, this study aims to evaluate the effect of resin variation with carbon nanotube (CNT) and aluminum powder additives in hybrid laminates on bending performance, as well as analyze failure results through macro photography [16] [17].

2. METHODS

This study employed the vacuum bagging method using epoxy resin and fiberglass. Variations were applied to the epoxy orientation by mixing it with carbon nanotubes and aluminum powder. The specimens were reinforced with aluminum plate layers before the bending tests were conducted. The specimen fabrication took place in the production laboratory of the Aeronautical Technology College (Sekolah Tinggi Teknologi Kedirgantaraan) in Yogyakarta, followed by bending tests at the DTMI Laboratory,

Universitas Gadjah Mada (UGM), Yogyakarta. The research was carried out over a period of approximately two months, from December 2023 to January 2024.

2.1 Research Stages

Based on Figure 1, the hybrid laminate manufacturing process involved several stages, beginning with SolidWorks design and ending with material finishing. The first step was creating a SolidWorks design, followed by cutting the base materials such as aluminum plate (series 1100) and fiberglass. Next, the surface of the aluminum plates was roughened, the resin was mixed, and the material was molded using the vacuum bagging method.

The specimen fabrication also used the vacuum bagging method with the following steps: selection of fiberglass, cutting the fibers, arranging the fiberglass layers, weighing the CNT and AL powders, mixing the resin with a specific ratio, applying resin and catalyst to the carbon fibers, and vacuuming the specimen for 3 hours. Afterwards, the specimen was removed, pressed, and prepared for further testing and analysis.

2.2 Observed Variables

The fixed variables in this study included: surface roughening of the aluminum face plate, specimen dimensions, number of fiberglass layers, vacuum pressure, epoxy resin, and pressing process. The independent variables were: plain epoxy, epoxy mixed with carbon nanotubes (CNT), and epoxy mixed with aluminum powder.

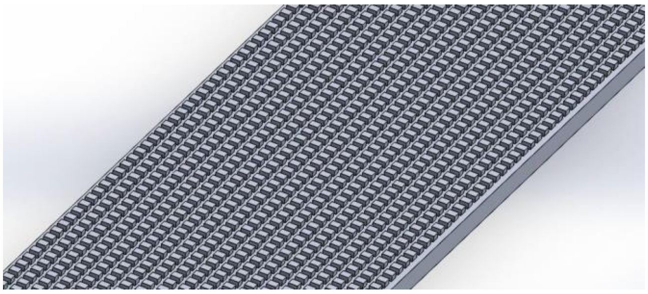

Figure 1. Image of roughing an aluminum surface with rectangular grooves

2.3 Data Collection Techniques

The data collection techniques include the tools and materials used in the fabrication of the specimens. Tools such as the bending test machine, scissors, measuring cups, rulers, digital scales, calipers, glass plates, iron plates, pumps, vacuum bagging machine, hoses, brushes, valves, and vacuum bagging plastic were required in the process. The materials used included fiberglass, aluminum 1100, carbon nanotube (CNT), aluminum powder, epoxy resin, hardener, wax molding, and industrial adhesive glue. All of these tools and materials have specific functions to ensure the specimens are well-fabricated. Their use followed the required specifications to achieve optimal results in this study.

3. RESULT AND DISCUSSION

3.1 Effect of Resin Variations with Carbon Nanotube (CNT) and Aluminum Powder on Bending Test

The initial step in specimen preparation involved gathering the necessary tools and materials. The aluminum plates and fiberglass materials were cut accordingly. The aluminum plates were cut using a fiber laser cutting machine at Universitas Gadjah Mada (UGM). The fiberglass was cut carefully to prevent damage and to match the required dimensions.

Following the cutting process, surface treatments were applied to the aluminum plates, which included roughening and creating square grooves. Roughening was done using 120-grit sandpaper, and the square grooves were manually inscribed using a scriber and ruler to ensure straight lines.

The first stage in specimen fabrication involved arranging the mold to prevent movement during the lay-up. The mold was constructed using small wooden sticks glued onto a glass plate that served as the base for fabrication. Next, the individual materials were weighed—two aluminum plates per specimen, five layers of fiberglass, and a pre-coating liquid mixture. The pre-coating mixture consisted of 90% acetone (45 grams) and 10% resin (5 grams). This mixture was then combined with 1% adhesive—either aluminum powder or CNT powder (0.5 grams)—to create the pre-coating solution. The main adhesive mixture used a 2:1 ratio of resin to hardener.

After the pre-coating solution was prepared, it was applied to the surface of the aluminum plates. Once it had partially dried, the specimen layers were assembled, consisting of pre-coated aluminum plates and fiberglass layers arranged in the mold. The entire lay-up was vacuumed and sealed in plastic for 3 hours to minimize voids and ensure proper bonding. After vacuuming, the specimens were pressed until dry, the plastic was removed, and the specimens were sun-dried.

The bending test was conducted to evaluate the strength of the fabricated material under specific loading conditions. A three-point bending method was used in the DTMI Laboratory at Universitas Gadjah Mada (UGM), Yogyakarta. A span length of 56 mm was determined using the formula 14 × h, where h is the average specimen thickness (4 mm).

During the bending test, the specimen was subjected to pressure, with the top side under compression and the bottom side under tension. The test results yielded data and graphs corresponding to each specimen variation. The following are the results of the bending tests that have been carried out:

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	POLOS -1	10.00	3.80	2.70	221.81	121.66
2	POLOS -2	10.00	3.80	2.67	303.66	166.55
3	POLOS -3	10.00	3.80	1.56	304.65	167.09
Average	0.0000	10.00	3.80	2.31	276.70	151.766

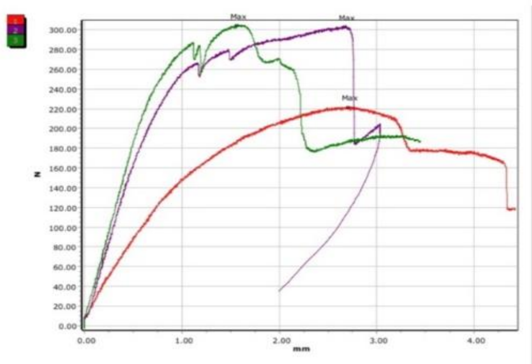

Figure 2. Graph of Plain Variation Results Without Line Flow

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	GARIS -1	10.00	3.50	1.49	239.51	154.85
2	GARIS -2	10.00	3.50	1.74	268.13	173.35
3	GARIS -3	10.00	3.50	6.12	243.58	157.48
Average	0.0000	10.00	3.50	3.12	250.41	161.8964

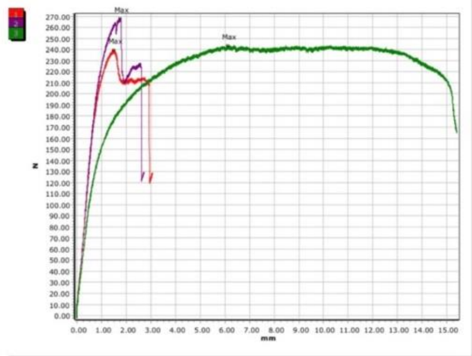

Figure 3. Graph of Variation Results with Surface Treatment

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	AL-1	10.00	3.90	2.21	265.76	138.38
2	AL-2	10.00	3.90	3.28	344.21	179.23
3	AL-3	10.00	3.90	2.21	256.78	133.71
Average	0.0000	10.00	3.90	2.57	288.92	150.4418

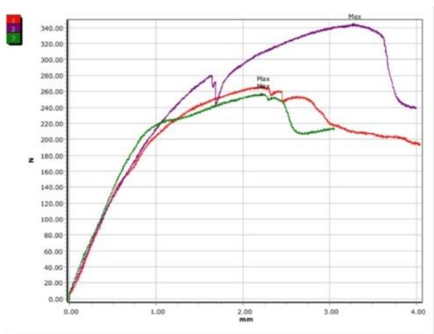

Figure 4. Graph of Variation Results with Surface Treatment and AL Powder

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	CNT-1	10.00	3.90	3.30	311.76	162.34
2	CNT-2	10.00	3.90	4.39	388.12	202.10
3	CNT-3	10.00	3.90	2.85	345.32	179.81
Average	0.0000	10.00	3.90	3.51	348.40	181.4158

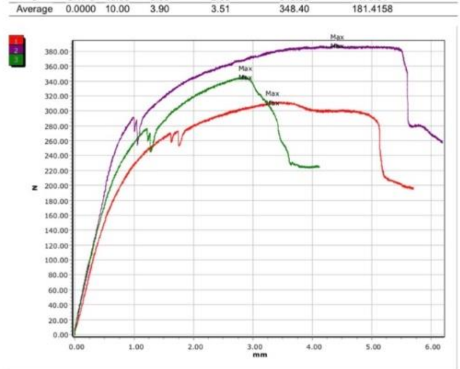

Figure 5. Graph of Variation Results with Surface Treatment CNT Powder

The purpose of conducting macro photography was to observe in greater detail the types of failure that occurred in each specimen with various treatments after undergoing the bending test. After the test, each specimen was disassembled and examined from all sides using appropriate equipment. The macro photography revealed both the best-performing and the poorest-performing specimens. The best results were observed in specimens with CNT powder adhesive, while the poorest performance was seen in the plain specimens without additional adhesive compounds or square-grooved surface treatment.

Below is the composition data of each specimen that was tested. This data was obtained by weighing the materials used in the fabrication of each specimen.

Table 1. Composition of Specimens to be Tested

No.	Kode Spesimen	Berat Fiberglass (gram)	Berat Plat Alumunium (gram)	Total Berat Spesimen (gram)
1.	Polos-1	1.34	4.28	7.12
2.	Polos-2	1.40	4.28	7.09
3.	Polos-3	1.71	4.28	7.05
4.	Garis-1	1.48	4.26	6.44
5.	Garis-2	1.45	4.29	6.50
6.	Garis-3	1.47	4.28	6.55
7.	AL-1	1.62	4.28	7.05
8.	AL-2	1.62	4.26	7.30
9.	AL-3	1.62	4.26	7.05
10.	CNT-1	1.44	4.20	6.86
11.	CNT-2	1.74	4.22	7.33
12.	CNT-3	1.68	4.21	7.18

All specimen variations share a common composition, namely the use of two aluminum plates to sandwich five layers of fiberglass. The difference between each specimen lies in the type of adhesive used. The plain variation only involved surface roughening and the application of resin as an adhesive, without any square groove treatment or additional adhesive reinforcement. In Variation 1 (Grooved), surface roughening and square groove treatments were applied, along with the use of resin as an adhesive. In Variation 2 (AL), surface roughening and square groove treatments were also applied, followed by the addition of resin mixed with aluminum powder as a nano adhesive. In Variation 3 (CNT), the same surface roughening and square groove treatments were applied, and the adhesive used was resin mixed with CNT powder as the nano adhesive.

Table 2. Density Values of Each Specimen Variation

No.	Material	Massa (Kg)	Volume (cm^3)	Nilai densitas (kg/cm^3)
1.	Polos-1	0,00191	0,940	0,00203191
4.	Garis-1	0,00221	1.144	0,00193182
7.	AL-1	0,00208	1,125	0,00184889
12.	CNT-3	0,00194	1,094	0,00177331

Table 3. Bending Test Values of Each Specimen Variation

No.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1.	Polos-1	10.00	3.80	2.70	221.81	121.66
2.	Polos-2	10.00	3.80	2.67	303.66	166.55
3.	Polos-3	10.00	3.80	1.56	304.65	167.09
Avg.		10.00	3.80	2.31	276.70	151.766

4.	Garis-1	10.00	3.50	1.49	239.51	154.85
5.	Garis-2	10.00	3.50	1.74	268.13	173.35
6.	Garis-3	10.00	3.50	6.12	243.58	157.48
Avg.		10.00	3.50	3.12	250.41	161.8964
7.	AL-1	10.00	3.90	2.21	265.76	138.38
8.	AL-2	10.00	3.90	3.28	344.21	179.23
9.	AL-3	10.00	3.90	2.21	256.78	133.71
Avg.		10.00	3.90	2.57	288.92	150.4418
10.	CNT-1	10.00	3.90	3.30	311.76	162.34
11.	CNT-2	10.00	3.90	4.39	388.12	202.10
12.	CNT-3	10.00	3.90	2.85	345.32	179.81
Avg.		10.00	3.90	3.51	348.40	181.4158

A comparison of the average maximum force across each specimen variation shows that the lowest average value was recorded in the grooved variation, with 250.41 N, while the highest value was observed in the CNT variation, with 348.4 N. The average bending stress values also varied, with the lowest found in the AL variation at 150.4418 MPa, and the highest in the CNT variation at 181.4158 MPa.

The bending tests conducted at the DTMI Laboratory, Universitas Gadjah Mada, Yogyakarta, yielded the lowest and highest average maximum force values. The lowest average was observed in the grooved variation at 250.41 N, while the highest was found in the CNT variation at 348.40 N. The increase in average maximum force with the addition of square groove surface treatment and CNT powder was confirmed by a 25.9% improvement. Conversely, applying surface treatment without nano adhesive resulted in a decrease in maximum force, demonstrated by a 10.5% reduction. It can be concluded that the addition of nano adhesive contributes to enhanced material strength. This improvement is due to the nano adhesive filling the micro-gaps in the surface-treated layers.

The reason for the lower performance in the plain and grooved variations is that these specimens did not utilize nano adhesive reinforcement. In contrast, the AL and CNT variations showed higher performance because they used adhesive mixtures reinforced with nano additives. It has been demonstrated that CNT powder significantly improves maximum strength, whereas the addition of square grooves without nano adhesive reduces the material's overall strength.

In terms of bending stress, the lowest average value was found in the AL variation (150.4418 MPa), and the highest in the CNT variation (181.4158 MPa). This is supported by percentage graphs indicating that CNT powder increased bending stress by 19.53%, whereas the addition of aluminum powder resulted in a 1% reduction in bending stress. Below is an explanation of the curves obtained from the bending test for each specimen variation.

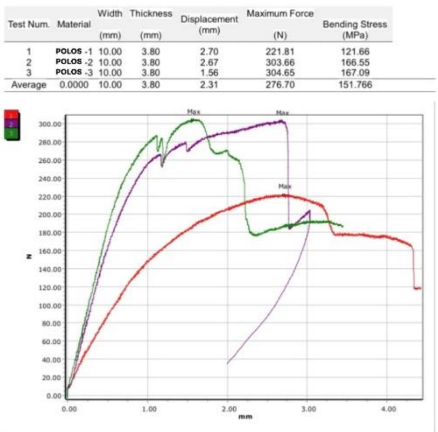

Figure 6. Plain Variation Specimen Curve

Based on the curve above, the plain variation specimen has an elastic region phase with an average value of 240.00 N, this variation gets an average ultimate stress value of 276.70 N, and an average fracture value of 250.00 N.

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	GARIS -1	10.00	3.50	1.49	239.51	154.85
2	GARIS -2	10.00	3.50	1.74	268.13	173.35
3	GARIS -3	10.00	3.50	6.12	243.58	157.48
Average	0.0000	10.00	3.50	3.12	250.41	161.8964

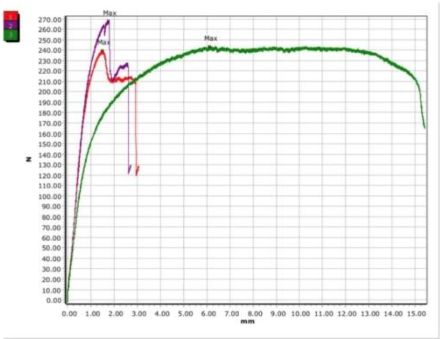

Figure 7. Line Variation Specimen Curve

The curve above shows a line variation specimen that has an average elastic region value of 190.00 N, has an average ultimate stress value of 250.41 N and the specimen has an average fracture value of 220.00 N.

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	AL-1	10.00	3.90	2.21	265.76	138.38
2	AL-2	10.00	3.90	3.28	344.21	179.23
3	AL-3	10.00	3.90	2.21	256.78	133.71
Average	0.0000	10.00	3.90	2.57	288.92	150.4418

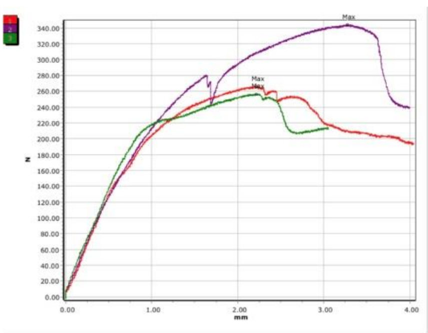

Figure 8. AL Variation Specimen Curve

Based on the specimen curve graph with AL variation above, the average value in the elastic region phase is 220.00 N, with an average ultimate stress value of 288.92 N, while the average fracture value of the specimen is 260.00 N.

Test Num.	Material	Width (mm)	Thickness (mm)	Displacement (mm)	Maximum Force (N)	Bending Stress (MPa)
1	CNT-1	10.00	3.90	3.30	311.76	162.34
2	CNT-2	10.00	3.90	4.39	388.12	202.10
3	CNT-3	10.00	3.90	2.85	345.32	179.81
Average	0.0000	10.00	3.90	3.51	348.40	181.4158

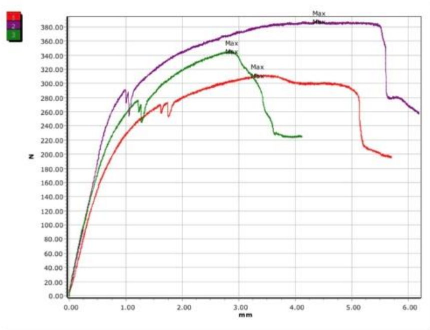

Figure 9. CNT Variation Specimen Curve

Based on the image above, it shows the curve graph of the CNT variation specimen so that the average value of the elastic region is 230.00 N, and the average value of the ultimate stress is 348.40 N and the average fracture value is 320.00 N.

3.2 Observation of Laminate Failure Bending Test Results When Viewed with Macro Photos

Below is the identification of the results of macro photos of two specimens with the highest and lowest results obtained based on the graph data above, so that the type of failure of the two specimens can be found. The failure that occurred to the specimen was adhesive and cohesive failure. The following is an image showing failure,

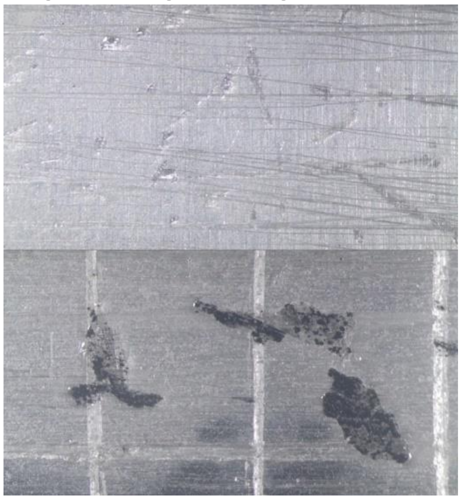

Figure 10. Observation of the Lowest and Highest Type Failure Variations

From the image above, it can be concluded that the specimen with the lowest strength value is the plain variation, the specimen experiences adhesive failure because the resin only sticks to one surface of the aluminum plate so that the other surface of the aluminum plate is lifted and cannot stick. This can happen because the specimen is not given a rectangular groove and nano adhesive so that the resin cannot bind perfectly.

While the CNT variation experiences cohesive failure because according to what is shown in the red circle there is resin with a mixture of CNT powder that sticks to the rectangular groove as it can be interpreted that the application of surface treatment accompanied by the addition of nano adhesive can increase the strength value of a specimen.

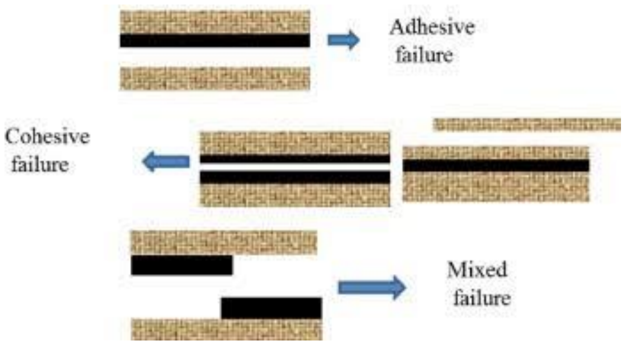

Figure 11. Type Failure

4. CONCLUSION

The bending test results on specimens reinforced by CNT and AL Powder show that the CNT specimen has a maximum strength of 348.40 N and the highest flexural strength of 181.4158 MPa. The main factors that influence are nano reinforcement and rectangular grooves. Macrophotographic observations show that plain specimens experience adhesive failure while CNT specimens experience cohesive failure. Further research is needed for hybrid laminate materials reinforced by CNT powder and AL powder with rectangular grooves so that the results are more optimal. It is hoped that this research can be a reference for further research for better results.

REFERENCE

T. F. Rachman, Pengaruh Jumlah Lapisan Fiberglass Terhadap Sifat Mekanik Body Pesawat Remote Control..

[H. Priono, "Analisis Material Komposit Fiberglass (Woven Roofing) Dengan Core Kayu Balsa Pada Pembuatan Pesawat Terbang Unmanned Aerial Vehicle (UAV) Bertipe Fixed Wing Model OV-10 Bronco," etd umy, 2020.

R. T. D. G. H. P. M. A. Bambang Setiawan, "Study Kelayakan Penggunaan Material Komposit Sebagai Campuran Resin Lycal Dengan Serat Sabut Kelapa Terhadap Gaya Impact Pada Pesawat RC," Teknik Mesin, 2022.

S. M. R. Ferriawan Yudhanto, "Karakterisasi Kekuatan Tarik Komposit Hybrid Lamina Serat Anyam Sisal dan Gelas Diperkuat Polyester," Ilmiah Semesta Teknika, vol. 19, 2016.

B. S. Siagian, Proses Manufaktur dan Kekuatan Tarik Glass Laminated Aluminium Reinforced Epoxy (GLARE), Yogyakarta: eprints STTA Yogyakarta, 2022.

H. Y. P. M. Pani Prima Tambunan, "Analisa Teknis Papan Laminasi Serat Bambu Petung Dengan Serat Fiberglass Woven Roving Untuk Material Kulit Kapal," Teknik Perkapalan, vol. 10, 2022.

A. S. Irza Sukmana, "Pengaruh Kecepatan Putar Indentor Las Gesek Puntir (Friction Stir Welding) Terhadap Kualitas Hasil Pengelasan Alumunium 1100-H18," Mechanical, vol. 7, 2016.

S. F. S. Fadhlah Hazhari, "Pengaruh Kekuatan Tarik dan Kekuatan Bending Komposit Hybrid dan Non-Hybrid Menggunakan Metode Vacuum Bagging," Teknik Mesin, vol. 2, 2022.

[9] F. S. I. R. P. D. A. M. Chandra Febriyanto, "Testing the Bending Strength of Carbon Fiber Composites using the Vacuum Infusion and Vacuum Bagging Method on the UAV Skywalker 1900 Fuselage Material," Material Science, vol. 6, pp. 9-19, 2023.

M. S. A. S. H. W. P. M. A. Tatang Wahyudi, "Pembuatan Komposit Carbon Nanotube-Polyvinyl Alcohol (CNT-PVA) Serta Evaluasi Sifat Mekaniknya," Tekstil, vol. 27, 2012.

T. E. S. Putri Ayu Anggoro, "Sintesis Carbon Nanotube (CNT) Menggunakan Prekursor Bahan Alam Serta

Modifikasi CNT Sebagai Komposit CNT/Resin Epoksi: Review," Kimia, vol. 6, 2021.

G. J. M. D. N. Indra Surya Iwanata, "Pengaruh Panjang Api Dan Sudut Injeksi Terhadap Produktivitas Mesin DC Thermal Plasma Dalam Pembuatan Nanopartikel Alumina," Stator, vol. 5, 2022.

M. M. E. F. H. W. H. I. F. B. P. Muhammad Fakhruddin, "Pengaruh Perlakuan Permukaan Pengikatan Terhadap Sifat Mekanik Komposit Serat Kaca Dengan Laminasi Almunium," Teknik Mesin, vol. 4, 2021.

M. F. I. O. M. Ghillan Ariyan Ditra, "Pengaruh Variasi Panjang Serat Fiberglass Bermatrik Plastik High Density Polyethylene (HDPE) Terhadap Kekuatan Bending Komposit," Teknik Mesin, 2018.

Ferry Setiawan, Chairul Amri, Indreswari Suroso, Muh Anhar, "Analisis Uji Bending Pada Spesimen Serat Kulit Jagung Fiberglass Dengan Perpaduan Resin Lycal Menggunakan Variasi Metode Pembuatan Vacuum Bagging Dan Vacuum Infusion" JAMERE,Vol 5 No 1 2025.

Ferry Setiawan, Muh Anhar, Akmal Akmal, Dhimas Wicaksono,, "Composite Material Impact Test With Resin Matrix And Kenaf Fiber Reinforcement Using The Hand Lay Up Method" JAMERE,Vol 3No 1 2023.

Muh Anhar, Yusuf Yusuf, Asep Ruchiyat, Etri Suhelmidati, Syarif Abdian Putra, Danial Danial, Yuli Yetri "Study of The Influence of Extract Cocoa Pods (Theobroma Cacao) as a Preservative Ingredient on Mahoni Woods (Swietenia Mahogany) Through Cold Soaking on Mechanical Properties, JRTPPI Vol 15 No 2 2024